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IDENTIFICATION OF RESPONSIBLE SOURCE FOR RISE IN GROUNDWATER TABLE OF JODHPUR CITY, RAJASTAN, INDIA

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ABSTRACT

Groundwater level has been rising in at least 40% of the land area in Jodhpur city, Rajasthan, India, which is raised up to hardly a few centimeters to five meters below the ground surface. In hard rock area, occurrence and movement of groundwater resources depends upon its geology and hydrogeology. From the detail interpretation of satellite imagery, a number of minor and major lineament sets have been identified. Hydrogeological studies based on the data of water table, rainfall and reference level of surface water of Kailana Lake reveal that rise in water table is mostly due to increase in water level of Kailana Lake-Takht *Sagar*. It has been inferred from the study that due to increase in the water level of Kailana Lake-Takht *Sagar*, the rate of seepage of lake water is more which passes through the lineaments, recharges the surrounding regions and contributes towards rise in water table of the city and its adjoining area.

KEYWORDS: Kailana Lake, Jodhpur City, Hydrogeology, Water Table Rise, Lineaments

INTRODUCTION

The groundwater occurrence, distribution and movement being subsurface phenomenon, its identification and location in any region is based on indirect analysis of some directly observable terrain features like physiography, drainage, lithology, geological structures and hydrogeology. The water which occurs below the surface of the earth usually held in cracks, fractures, porous and permeable rock formations is called subsurface water or groundwater and the water which occurs above the surface of the earth is called surface water. If both surface and subsurface water are interlinked to each other, then it causes rise in water table. Meinzer (1942) used terminology like plerotic and kremestic for subsurface water. The first term designates water occurring in the zone of saturation while later term is used for water in the zone of aeration. The depth of subsurface up to the saturated zone is called the water table. The water table may be present at deep or shallow depth and its rise and fall depend on many factors. Heavy rains or melting snow causes rise in water table and extended period of dry weather causes fall in water table.

Although large part of India is presently facing the problem of decline of the water table, ironically anomalous rise in groundwater table in some parts of Jodhpur city is being observed and has become a cause of concern. The drinking water supply of Jodhpur city is done mainly from Kailana Lake-Takht *Sagar* which is connected with the Rajiv Gandhi Lift Canal (RGLC) supplying water to the reservoir continuously. To fulfill the ever increasing demand of the growing population, the storage capacity of the reservoir has been increased which resulted in enhancement of the water level of the reservoir. Since last few years regular rise of water table in the Jodhpur city and adjoining area has drawn attention due to its adverse effect reported in the region. The problem was visualized when subsoil water started oozing out in the underground structures of a number of shops situated in the heart of the city during March 1998. Since then the groundwater table has been continuously rising approximately 1.0 m per year in old walled city and adjoining area. The

problem therefore requires proper study of affected area and its surroundings to find out the recharging source and flow path which causes the rise in water table.

Keeping this in view, attempt has been made to analyze the data of groundwater table, rainfall and water level of Kailana Lake along with the satellite imagery to identify the probable recharging source of groundwater which causes rise in groundwater table in the area under investigation (Pratap, 2006).

PHYSIOGRAPHY, GEOLOGY AND HYDROGEOLOGY

Physiography

The study area comprises the lands of Jodhpur city and its adjoining area which covers about 172 Km^2 as shown in Figure 1. Geographically, it is situated in the western part of the Rajasthan lying between the Latitudes 26^0 13'N to 26^0 20'N and Longitudes 72^0 56'E to 73^0 04'E. The study area falls under the Survey of India toposheets having numbers 45F/3, 45F/4, 45B/15 and 45B/16.

Jodhpur city is situated partly along the foot of hills and partly in the plains formed by weathering of rhyolite and sandstone. Major part of the old city lies on the pediment zone. City is bounded by the hills in the north and west directions. The hills of rhyolite rise to an elevation of 395m above mean sea level and present the prominent elevated landmark features in the western part of the area near Kailana Lake. Topographic lowering of the plain are to the extent of 210m above the mean sea level (MSL) which occurs in the south-eastern part of the area as shown in Figure 2.

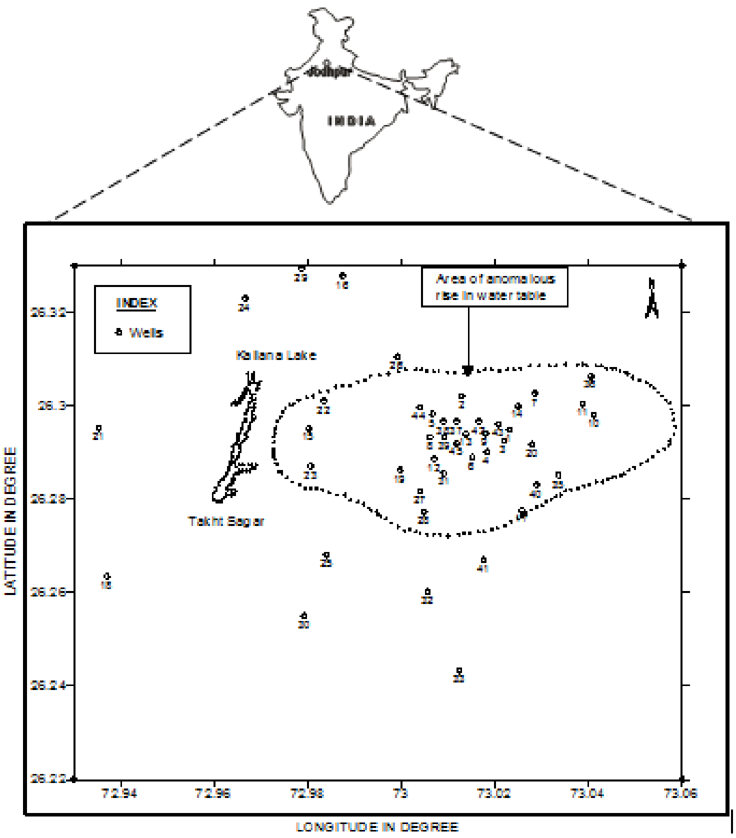

Figure 1: Location Map of the Study Area Showing Existing Water Wells Monitoring Stations

North eastern part of the area is occupied by outcrops and pediments of rhyolite and sandstone. Isolated outcrops

of granites are exposed near Jodhpur University and Jhalamand in the south. Rest of the area comprises of alluvial plains with gentle slope towards south to south-east direction. The average elevation of the ground is about 260m and highest hill is 395m from MSL close to the radar hill near Kailana Lake area. Most of the other hills are having 300m to 340m elevation. The Jodhpur railway station lies at an elevation of 241m from MSL. There are eight small and medium water bodies situated within study area, viz. Kailana Lake-Takht *Sagar*, Ummed *Sagar*, Jaswant *Sagar*, Lal *Sagar*, Gulab *Sagar*, Rainsar, Padmasar and Bal Samand.

The city sewerage is directed to Jojari River in southeastern direction through various drains. The drainage pattern is not fully developed in the area. However, there are several small nallahs which start from sandstone and rhyolite hills and join main streams. Near the foot hills, the deposition of blown sand turns into deep gullies due to run-off from the hills. In some places uncontrolled run-off from these streamlets and nallahs has resulted in a considerable gully and sheet erosion in the area. The main ephemeral streams in the area are the Golasni and Jojari Rivers.

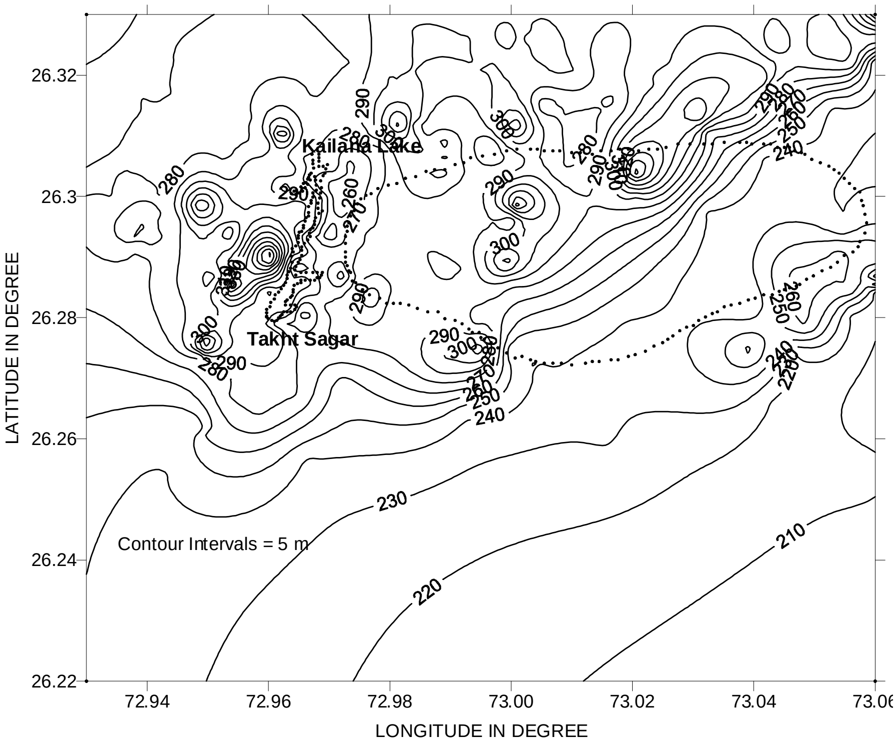

Figure 2: Physiography Map of the Study Area

Geology

The geological formations of Jodhpur city and adjoining area are mainly composed of sedimentary rocks like sandstone, shale and limestone of Vindhyan super group with certain areas occupied by rhyolite suite (Blanford, 1877; Paliwal, 1992). These formations are highly deformed due to tectonic activities. It is believed that during these tectonic processes some major lineaments were developed and extended up to several kilometers towards the city area.

In the city, the geological formations like Malani rhyolite and Jodhpur sandstone are inter-layered with shale. The lower flow of Malani rhyolite is highly faulted, folded, weathered and fractured due to tectonic processes. Kailana Lake and Takht *Sagar* are also situated on this type of rock formation. The Jodhpur group of rocks like shale and sandstone cover maximum area of old walled city. The shale and sandstone are deformed due to Neotectonic activity of the area. A

large number of parallel faults trending NE-SW and NW-SE directions have developed in Jodhpur city. A number of parallel joints trending NE-SW and E-W directions have also developed in rhyolite, shale and sandstone formations due to Neotectonic activity.

Hydrogeology

Malani rhyolite, Jodhpur sandstone and quaternary alluvium are the hydrogeological formations in the study area. Groundwater in the area occurs under water table conditions. The water table variation is mainly controlled by aquifer characteristics. The different sets of joints, faults and fractures as well as clayey material and ash beds play very important role in the circulation, distribution and movement of groundwater. Yield of the aquifer varies widely depending on the porosity, permeability and availability of weathered and fractured zones. The hydrogeological formation of the study area have been classified based on the geological study of the bore hole sections, examination of open dug wells and groundwater occurrence in different litho units. Hydrogeologically, the Jodhpur sandstone is divided into two categories: one is shale intercalations with shaly sandstone showing fine to medium grained nature and other is medium to coarse grained sandstone in pebbly to conglomeratic forms.

Climate and Rainfall

The area under investigation falls under the categories of arid and semi-arid climate characterized by high evaporation, extremes of temperature intermittent and uncertain rainfalls. The winter season, which starts in November lasts up to February, is followed by summer lasting up to June. The climate of the area is dominated by the south-west monsoon which generally starts by the first week of the July and withdraws from the region by the second week of September. There is a good variation in maximum and minimum temperatures during summer. The maximum temperature often exceeds 45^{0}C, especially during May and June when hot waves prevail over the region. In contrast during December and January the mean night temperature often records 6 - 10^{0}C. Sometimes in the winter minimum temperature reaches the freezing point due to several cold waves associated with western disturbances.

Rainfall is erratic and extreme variations occur even in a small area. This phenomenon mostly occurs in spells and break off for about a week or two in which rainfall activity is least over the region. The monsoon rains cover an average of 88% - 90% of the annual rainfall. Nearly 77% - 80% of the monsoon rainfall occurs in the month of July and August. The mean annual rainfall of the area is 391 mm (1971 - 2002) and normal annual rainfall is 296 mm. The rainfall intensity declines as we move from east to west outside the Jodhpur city. The air is generally dry during the major part of the year. However, during monsoon period the climate becomes a little humid, relative humidity is highest in the month of August (81%).

MATERIALS AND METHODS

The satellite imagery has been utilized to identify the presence of lineament, prominent water body, and many of the ridges and hills lie in the area under study. Initially the water table data were collected at 21 monitoring stations. Ten more observation wells were selected in the affected area between 1998 to March 2000, which reached up to 31 in number. The water table data of Pre- and Post-monsoon period starting from 1994 to 2001 were taken for the study. Apart from these, monthly water table data were also recorded at few places in the study area as shown in the location map (Figure 1). The water table variation, hydrograph, water table trend at the particular station and water table contour maps of the area have been prepared and discussed in the following sections. Trend analysis of groundwater table has been carried

out based on the detailed hydrogeological studies. In these analyses various types of data such as rainfall, groundwater table and water level of Kailana Lake-Takht *Sagar* were utilized to show the comparative variations. Few representative examples have been presented and discussed below. For clarity, the data for groundwater table, rainfall, and reference water level data of Kailana Lake-Takht *Sagar* is presented in Table 1, Table 2, and Table 3, respectively.

DISCUSSIONS OF RESULTS

Lineament

A lineament is defined as a regional large scale linear or curvilinear feature, pattern or changes in pattern that can be identified in a data set and attributed to a geological formation or structure (Qureshi, and Hinze, 1989). Lineaments provide the pathways for groundwater movement and are hydrogeologically very important (Sankar et al., 1996).

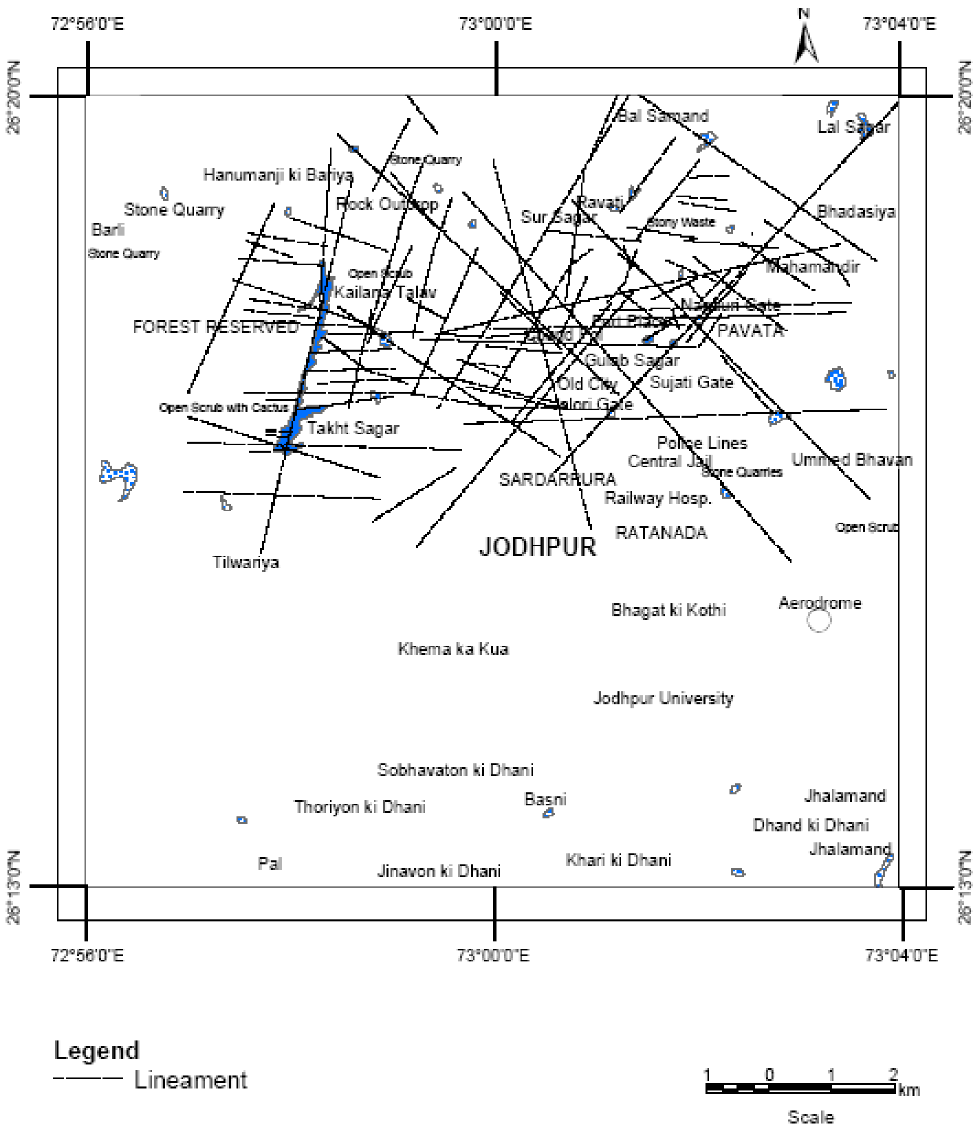

Figure 3: Lineament Derived from the Satellite Imaginary

Based on the interpretation of satellite imagery a number of lineament sets traversing NNE-SSW have been identified and presented in the Figure 3. The prominent water body viz. Kailana Lake-Takht *Sagar* and Bal Samand and many of the ridges and hills lie along these lineament sets. Apart from these, large numbers of prominent Joints traversing E-W direction and other sets in NW-SE, WNW-ESE and NNW-SSE directions are clearly shown in the figure. The

signatures of these lineament sets are not clear from the satellite image in the city area. It is expected that many of these Joint sets continue in same direction in the city area below the ground surface. Two very prominent lineaments, one originates near Kailana Lake-Takht *Sagar* and continues for quite long distance eastward and centrally aligns towards Baiji ka *talab* and other water body east of it, second lineament aligns Gulab *Sagar* and Fateh *Sagar* in the city area. Most of the lineaments originated from Kailana Lake-Takht *Sagar* and passed towards city through Dau *Ki Dhani* and Ahkeraj ji ka *talab* influence water movement between these regions due to their interconnectivity. In the rhyolite hills, this provides easy conduit for movement of groundwater towards city area.

Hydrogeological Studies

Groundwater Table

The groundwater table is highly variable from place to place. Chopasni Housing Board, Shastri Nagar, Sardarpura and up to the Ratanada (the rhyolite is followed by recent alluvium) show average water table fluctuation between 15m to 39m below ground level (bgl). The average depth of water table varies from 5m to 35m in the alluvial covered region. The quality of groundwater varies from potable to highly saline.

The depth to water table in the area varies from 0.5 m to 33.9 m based on pre-monsoon 2001 data at various places due to different hydrological formations and structures. Shallow water table (less than 5m bgl) was observed in old walled city as well as north-east part of the city. Very shallow groundwater table (less than 3m) was observed in some parts of the area. The groundwater overflowed at the surface near Gulab *Sagar*, Fateh *Sagar*, and Gorinda Baori and nearby places. The basements and foundation of the buildings in this region were fully saturated with groundwater and seepages were reported.

Hydrographs

The water table data collected at different monitoring stations were used for the preparation of hydrographs. There are two categories of hydrographs. The monitoring wells having rising trend of water table and lying within the anomalous area are considered in the first category. The second category of monitoring wells covers those lying away from the affected area. Few representative examples have been presented in this section, out of several monitoring stations having different periods of observations. For the simplicity, these hydrographs were prepared taking the data of continuous pre-monsoon and post monsoon periods. The entire data of five monitoring stations, namely (a) W-31, (b) W-28 and, (c) W-25, (d) W-14, and (e) W-2 have been incorporated to show the variations in the water table which is presented in Figure 4. In this figure, curves (a) and (b) show the variation of water table for the period of 1994 – 2001 whereas curves (c), (d) and (e) show the variation of water table for the period of 1996 – 2001. All the curves show the rising trend of water table during the entire period of study at each station. This fact clearly shows that there is continuous supply of water through the underground sources which may be interconnected through the lineaments with surface reservoirs existing in their close vicinity. However, the trend of water table of some other observation wells, which are not presented here, has either very little rise or no change at all as they are far away from the affected area. This type of observed behaviour at these monitoring stations may be due to the fact that these stations are neither influenced by any extra recharging source nor connected through any of the surface reservoir.

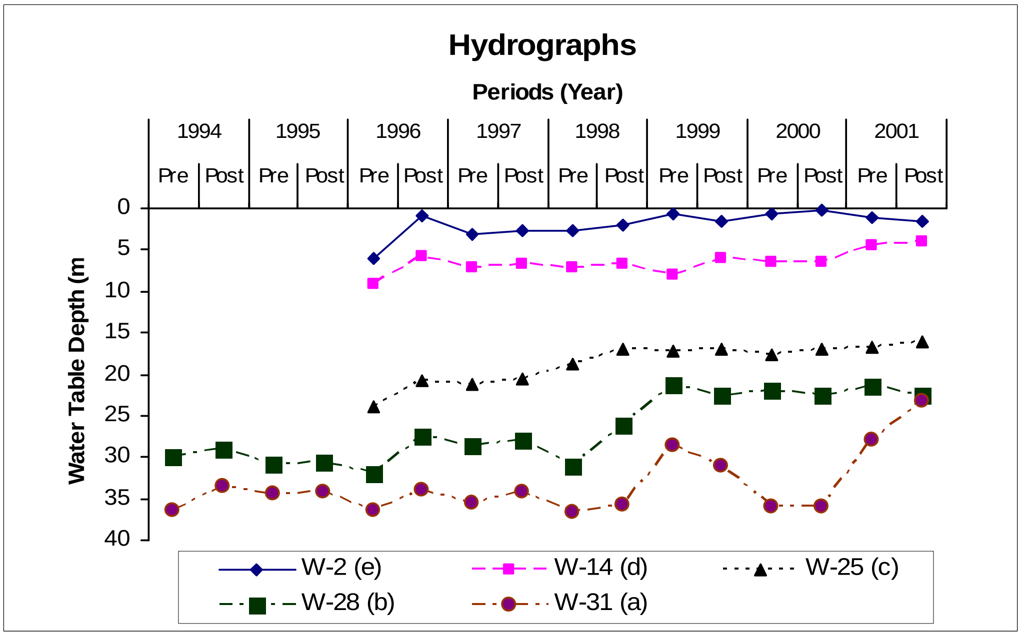

Figure 4: Hydrographs for Monitoring Stations, Namely: (a) W – 31, (b) W – 28, (c) W – 25, (d) W – 14, and (e) W – 2.

Trend Analysis and its Correlations

In the trend analyses various types of data such as rainfall, groundwater table and water level of Kailana Lake-Takht *Sagar* were utilized to show the comparative variations. Few representative examples have been presented and discussed below.

The total rainfall during monsoon season versus time period from year 1971 to 2001 has been presented in Figure 5. Figure shows too much fluctuation in the rainfall during these years. The trend analysis for the above period shows that the tendency of rainfall is almost constant and shows no significant variation. Further, if we examine the rainfall variation for the starting period i.e. 1996, then also the trend is almost showing similar tendency. It is therefore inferred that the possibility of contribution of rainfall towards rise of water table is very limited or almost negligible.

Figure 5 shows the correlation of water table data of W-5 with water level data of Kailana Lake during post-monsoon season of 1994 to 2001. The figure has been drawn while taking time period on the x-axis whereas left hand side of y-axis contains water level of Kailana Lake and right hand side of y-axis contains depth of water table. A regression line is fitted with water level data of Kailana Lake, which is shown by continuous bold line. Another regression line is also fitted with water table data of a monitoring station. The increase in water level of Kailana Lake fully correlates with the rise in water table.

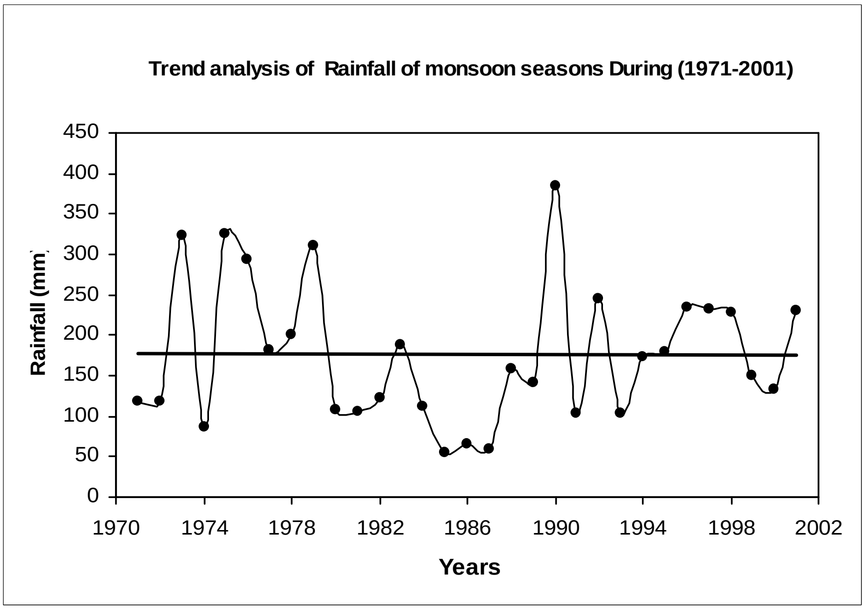

Figure 5: Map Showing the Variation in the Monsoon Total Rainfall for the Period (1971-2001)

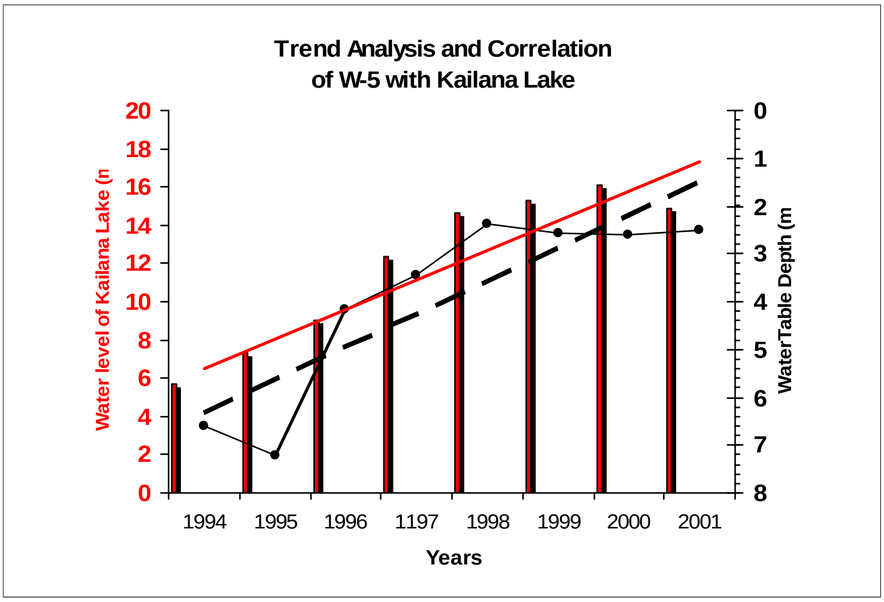

Figure 6: Comparison of Trends of Water Table of W-5 and Water level of Kailana Lake for the Period (1994-2001)

Water Table Contour Maps

The depth of water table was converted with reference to the mean sea level as a reference level (RL) of water table. The contour maps of RL of water table have been prepared for pre- and post-monsoon seasons for the entire study period of 1994 – 2001. Out of these contour maps only few representative contour maps are presented and discussed.

Two contour maps (Figures 7a, b) for the pre-monsoon and two contour maps (Figures 8a, b) for the post-monsoon seasons have been presented to show the hydraulic gradient of the area. Figure (7a) shows the contour maps of water table (RL) of pre-monsoon of 1998 and Figure (7b) shows the contour map for the same season of 2000. Similarly, Figures (8a, b) show the contour maps of post- monsoon season of 1998 and 2000, respectively. The

comparative studies of these figures clearly indicate that pattern of the contours are similar in nature whereas the magnitude of the highest value of contour for the year 2000 is slightly higher. In all the figures, the highest value of water level is located in the north-east corner having the latitude range of 26.29^0 to 26.31^0 and the longitude range of 72.94^0 to 72.96^0. The magnitude of lowest value of contour is 170 m for both the years and seasons and is centered in the south-east portion of the area having latitudes 26.22^0 to 26.26^0 and longitudes 73.00^0 to 73.05^0. The flow of water starts from the higher altitude to the lower altitude of RLs of water table. In the area under study, the flow of water is predominantly in two directions namely, east and south-east. However, the hydraulic gradient is steeper in the eastern side compared to the south-eastern side.

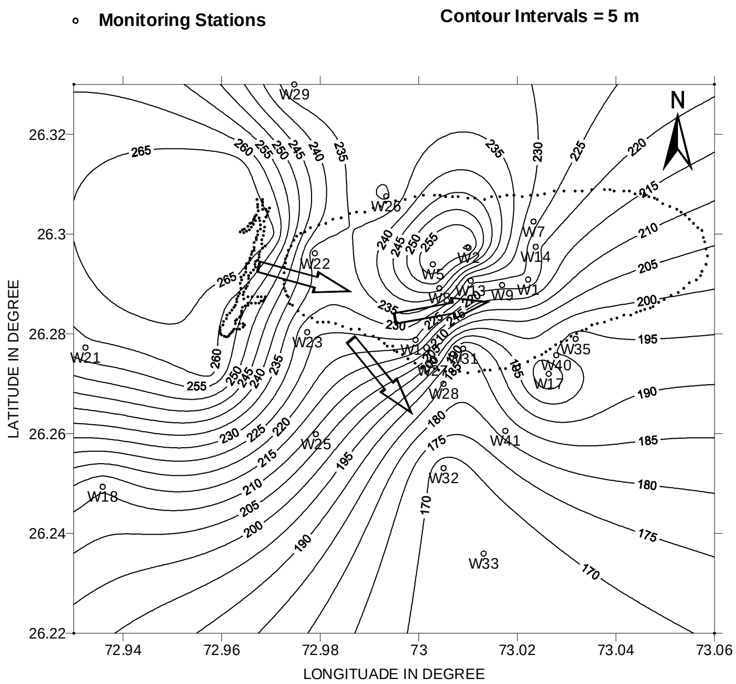

Figure (7a): Contour Map Showing the Groundwater Reference level (GWRL) Around Jodhpur City during Pre-Monsoon, 1998

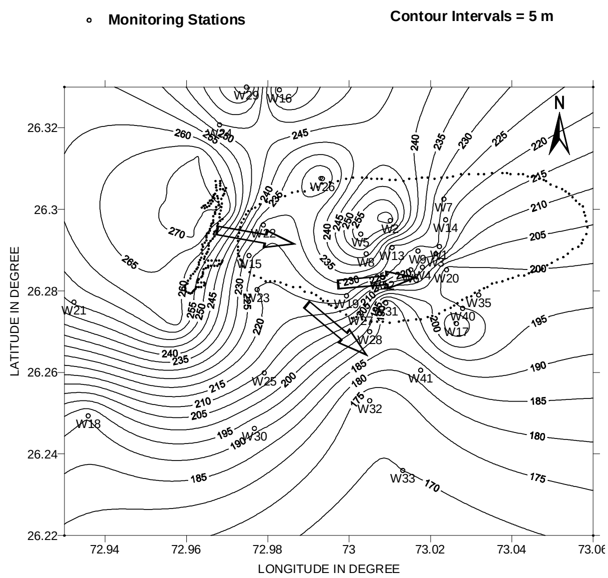

Figure 7b: Contour Map Showing the Groundwater Reference Level (GWRL) Around Jodhpur City during Pre-Monsoon, 2000

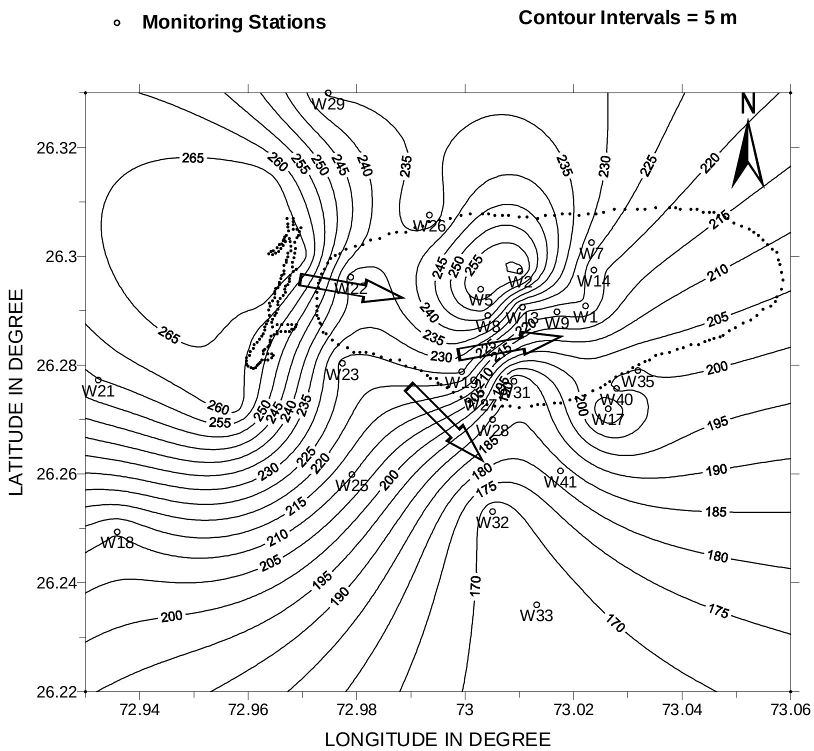

Figure (8a): Contour Map Showing the Groundwater Reference level (GWRL) Around Jodhpur City during Post-Monsoon, 1998

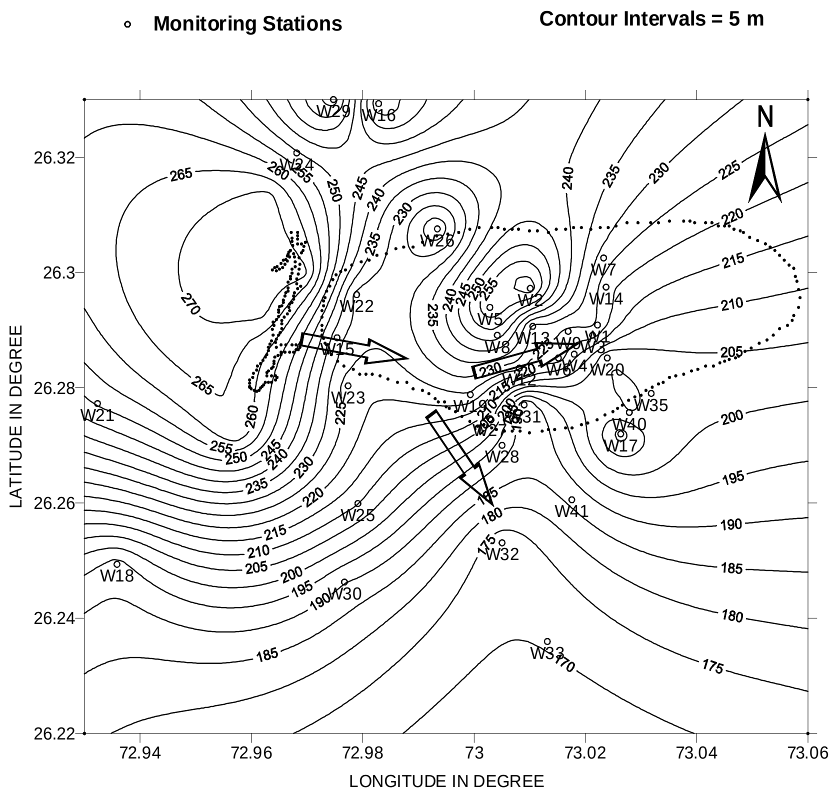

Figure (8b): Contour Map Showing the Groundwater Reference level (gwrl) Around Jodhpur City during Post-Monsoon, 2000

CONCLUSIONS

From the trend analysis, it is observed that water table is continuously rising during entire period of study. It implies that there is continuous supply of water through the underground sources which may be interconnected through the existing lineaments with surface reservoirs, i.e. Kailana Lake-Takht *Sagar* lying in the close vicinity of the area. However, some portion of the area shows either no change at all or very little rise in water table which may be due to the fact that these parts are neither influenced by any extra recharging source nor connected through any of the surface reservoir as they are far away from the recharging source. The trend analysis of rainfall shows that the possibility of contribution of rainfall towards rise in water table is quite negligible.

The increase in water level of Kailana Lake fully corresponds with the rise in water table at many places. The increase in the level of Kailana Lake would create more hydrostatic pressure causing percolation of water towards weak zones. As these weak zones are interconnected through lineaments up to the affected area, it can be inferred that rise in water table may be due to increase in water level of Kailana Lake-Takht *Sagar*. This is also supported by the flow direction of water in the area.

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APPENDICES

Table 1

Well No.	1994		1995		1996		1997		1998		1999		2000		2001	
	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post. (m)	Pre. (m)	Post.
W-1	-	-	-	-	4.19	1.00	1.55	1.13	1.47	1.00	1.58	0.70	0.85	0.95	0.65	0.64
W-2	-	-	-	-	6.10	1.00	3.05	2.70	2.68	2.02	0.66	1.65	0.75	0.20	1.22	1.40
W-3	-	-	-	-	-	-	-	-	-	-	-	-	1.83	1.53	1.40	1.10
W-4	-	-	-	-	-	-	-	-	-	-	-	-	1.50	1.60	2.58	1.48
W-5	8.70	4.50	7.50	6.95	5.40	2.90	3.92	2.95	2.48	2.30	2.43	2.70	2.64	2.54	2.60	2.52
W-6	-	-	-	-	-	-	-	-	-	-	-	-	0.85	0.98	3.00	3.12
W-7	4.25	3.63	5.2	4.85	4.85	-	3.50	-	3.87	2.86	5.70	3.10	6.08	2.68	3.19	2.50
W-8	-	-	-	-	3.45	1.50	1.00	1.10	1.16	1.02	1.24	1.21	1.00	1.00	3.28	1.70
W-9	-	-	-	-	9.16	8.35	8.79	5.30	5.10	5.23	4.58	4.56	5.06	3.68	3.96	2.90
W-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.20	3.40
W-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.29	5.35
W-12	-	-	-	-	-	-	-	-	-	-	-	-	4.00	4.18	4.32	4.30
W-13	-	-	-	-	8.85	6.55	7.10	6.55	8.16	6.88	7.40	6.30	6.85	6.15	5.35	4.22
W-14	-	-	-	-	9.15	5.82	7.10	6.60	7.05	6.62	8.10	6.00	6.46	6.50	4.52	4.20
W-15	-	-	-	-	-	-	-	-	-	-	-	-	12.05	6.10	7.50	3.90
W-16	11.25	8.05	10.75	4.50	3.70	2.80	6.50	2.70	-	-	8.42	8.72	10.16	10.06	7.830	1.70
W-17			20.44	20.20	21.00	15.00	12.75	10.49	13.05	8.40	8.00	10.50	7.15	6.55	6.46	5.46
W-18	17.45	17.03	17.95	14.10	11.00	3.05	4.15	4.15	5.05	5.35	5.95	9.17	25.33	22.83	17.18	6.63
W-19	13.60	9.20	11.24	11.10	12.62	7.75	9.60	8.95	7.83	6.87	7.47	7.55	8.08	8.08	7.56	7.04
W-20	-	-	-	-	-	-	-	-	-	-	-	-	10.63	7.03	-	7.50
W-21	16.00	16.32	13.60	13.50	13.50	13.35	11.38	10.47	11.35	15.17	18.10	17.93	19.05	19.33	14.10	11.09
W-22	17.02	16.85	17.15	17.36	17.36	6.00	7.95	6.50	8.10	7.03	8.24	12.15	12.15	12.00	-	9.61
W-23	-	-	-	-	-	-	-	-	9.85	12.57	13.05	13.28	16.18	13.90	-	12.00
W-24	-	-	-	-	-	-	-	-	-	-	-	-	20.17	15.00	19.05	15.52
W-25	-	-	-	-	24.00	20.75	21.15	20.50	18.70	17.05	17.12	16.90	17.62	17.09	17.95	16.20
W-26	11.4	8.55	20.45	18.80	22.95	8.90	9.15	8.15	11.26	8.74	13.60	12.63	16.35	24.81	18.65	10.50
W-27	-	-	-	-	36.10	33.95	34.35	32.3	31.65	27.23	27.69	26.80	26.06	26.15	24.39	23.28
W-28	30.00	28.99	30.8	30.60	32.00	27.45	28.70	27.85	31.10	26.25	21.19	22.49	22.00	22.60	21.39	20.09
W-29	-	-	18.55	18.37	18.67	15.88	17.65	16.40	22.05	18.13	20.05	25.90	26.55	25.97	26.59	20.88
W-30	-	-	-	-	-	-	-	-	-	-	28.50	27.85	25.56	26.57	24.70	23.98
W-31	36.42	33.60	34.47	34.30	36.50	34.00	35.60	34.15	36.57	35.73	28.71	31.09	35.87	36.00	28.00	20.35
W-32	-	-	-	-	-	-	-	-	33.58	33.53	32.04	31.97	30.10	29.02	-	27.18
W-33	-	-	-	-	-	-	-	-	37.90	36.47	34.09	33.8	33.97	33.17	-	32.37
W-34	-	-	-	-	-	-	-	-	44.89	48.10	41.28	48.05	49.69	55.51	-	30.30
W-35	-	-	-	-	-	-	-	-	17.15	10.36	13.21	10.47	14.12	9.14	10.70	7.50
W-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.91
W-37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.20
W-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.66
W-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.25
W-40	-	-	-	-	-	-	-	-	12.30	8.55	7.57	6.40	7.40	7.58	7.20	4.91
W-41	-	-	-	-	-	-	-	-	25.10	23.98	21.01	20.46	24.44	20.71	19.32	18.75

Table 1: Contd.,

W-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.80
W-43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.70
W-44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.55
W-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.40	6.20

Table 2: Rainfall Data of Jodhpur City (in mm) During 1994 - 2001

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1994	24.0	0.0	0.0	18.0	6.0	8.0	149.0	135.0	56.0	0.0	0.0	0.0
1995	0.0	0.0	1.0	0.0	0.0	16.2	283.8	60.0	1.0	13.0	0.0	0.0
1996	0.0	0.0	2.0	6.0	24.3	148.4	66.7	243.0	10.0	0.0	0.0	0.0
1997	0.0	0.0	3.0	0.0	19.5	81.0	61.0	317.0	5.1	82.0	8.0	0.0
1998	0.0	0.0	11.0	20.5	0.0	175.0	36.0	97.5	146.0	93.0	0.0	0.0
1999	5.0	17.0	0.0	0.0	11.5	56.5	52.0	182.0	11.0	17.0	0.0	0.0
2000	0.0	0.0	0.0	2.0	5.0	13.0	219.0	32.0	2.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	5.5	57.5	91.0	255.0	110.0	5.0	4.0	0.0	0.0

Table 3: Reference Water Level of Kailana Lake during 1993 - 2000

Month\ Year	2000	1999	1998	1997	1996	1995	1994	1993
January	272.77	272.62	272.62	272.62	263.58	264.11	259.14	262.41
February	268.53	271.55	271.55	271.55	262.66	263.2	259.28	262.31
March	270.74	271.75	271.75	271.75	264.52	263.26	259.43	262.2
April	271.61	272.25	272.25	272.25	262.86	261	258.59	262.05
May	272.52	270.27	270.27	270.27	263.31	259.96	259.45	261.99
June	272.83	269.35	269.35	269.35	265.24	259.75	259.35	258.53
July	272.33	269.95	269.95	269.95	262.75	266.82	265.02	262.52
August	271.49	270.24	270.24	270.24	267.01	263.97	264.14	257.37
September	272.16	270.53	270.53	270.53	264.99	262.98	264.16	257.11
October	273.38	271.46	271.46	271.46	267.2	265.57	264.32	259.05
November	273.38	272.49	272.49	272.49	268.96	264.67	264.23	259.26
December	273.47	273.42	273.42	273.42	265.85	264.45	263.53	258.74